Changes in OLR over Arctic as Depicted by AIRS, CERES, and MERRA-2

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Motivation

Part I.

Identifying characteristics and the levels of agreement in OLR data sets is a key to understanding our radiation driven planet.

- products covering the 14 year period since September 2002 through August 2016:
  - CERES EBAF Edition 4.0
  - AIRS Version-6
  - MERRA-2

Part II.

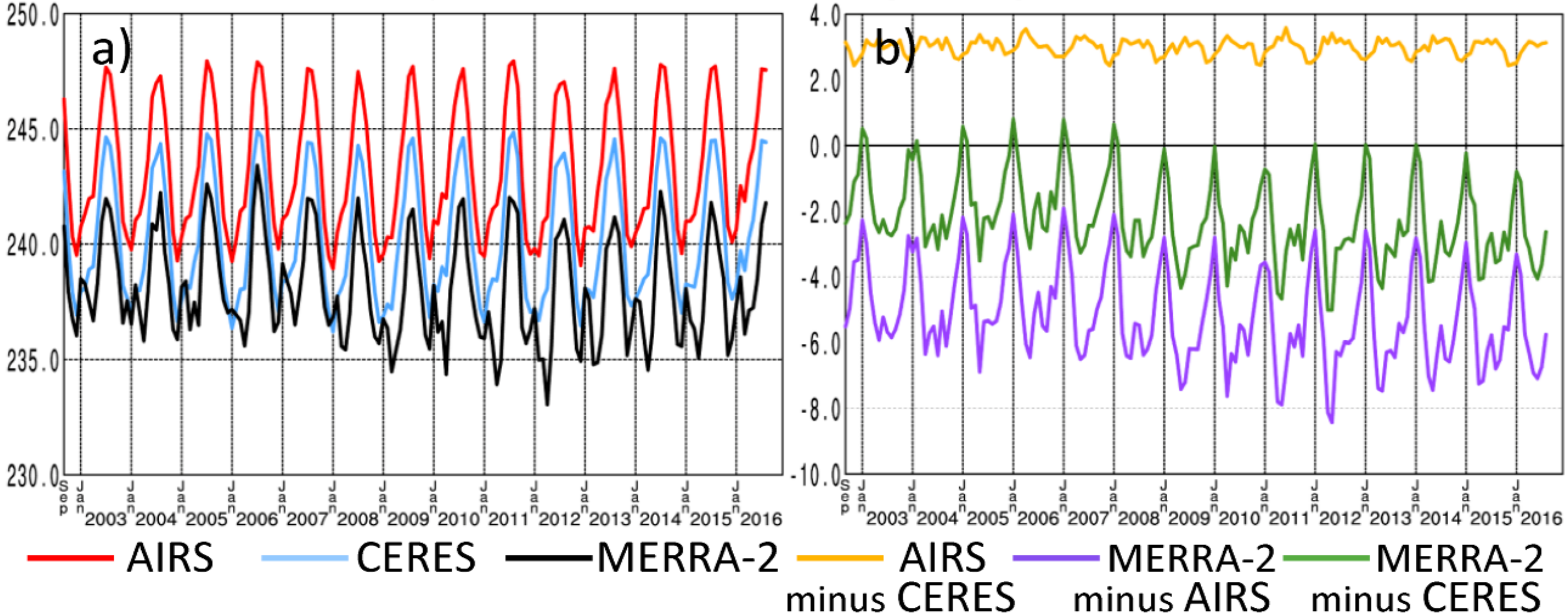
Where and how much OLR and LWCRF changed over Arctic?

Does historical TOVS OLR data help to address the near term trends?

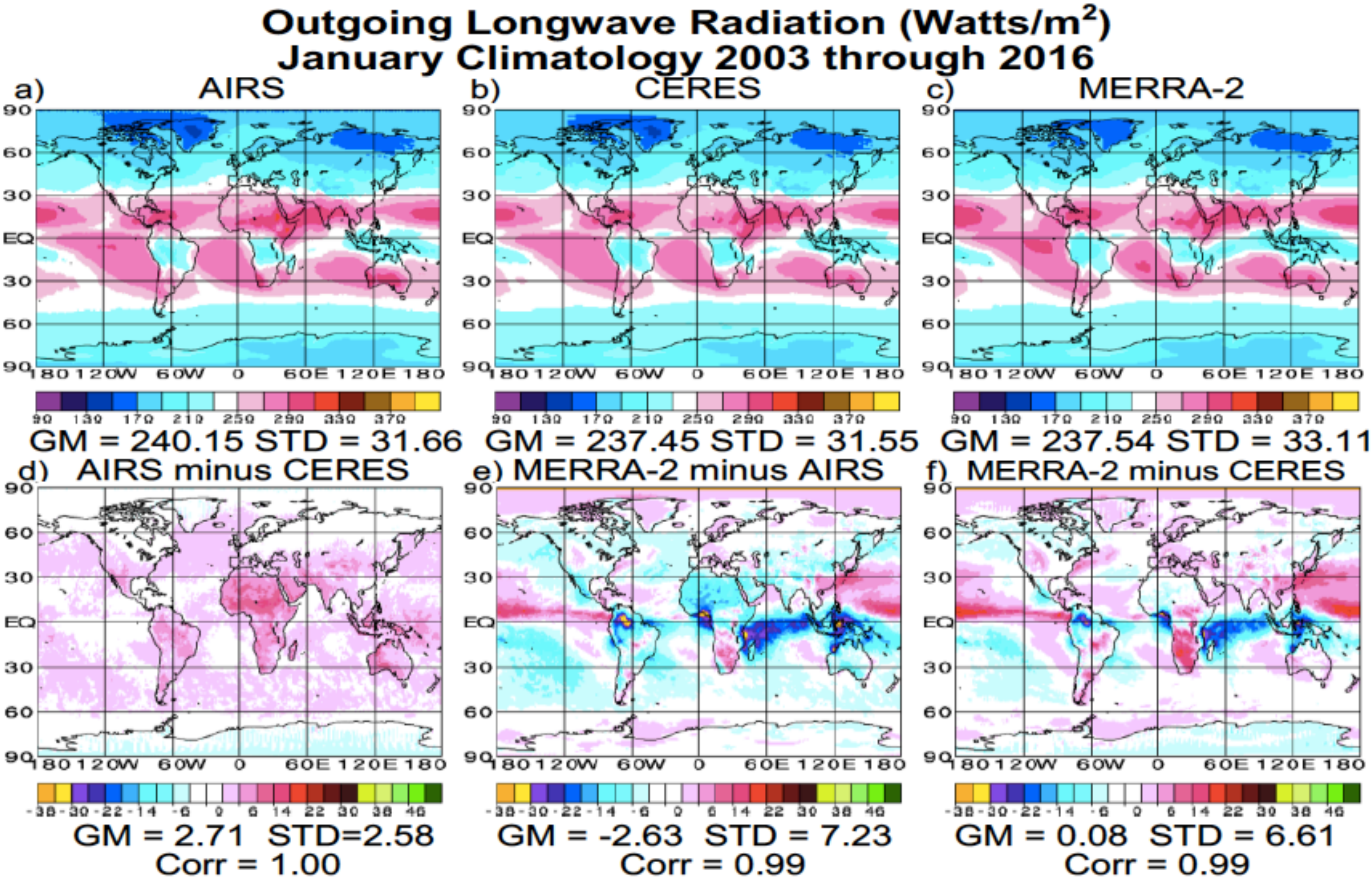
AIRS, CERES, and MERRA-2 OLR Data

- AIRS Version-6 OLR is computed using an OLR RTA in conjunction with retrieved geophysical parameters.
  AIRS data shown use the average of the AIRS products generated separately at roughly 1:30 AM and 1:30 PM local time.
- CERES_EBAF Edition 4.0 OLR is derived from measured fluxes. CERES OLR represents what would have been observed if measurements were taken over the course of the whole day.
- MERRA-2 OLR is a computed product, generated on a grid point basis every 6 hours, 0Z, 6Z, 12Z, and 18Z. MERRA-2 uses a different OLR RTA than does AIRS, and uses model generated, rather than retrieved geophysical parameters.

Global Outgoing Longwave Radiation (Watts/m^2)
September 2002 through August 2016

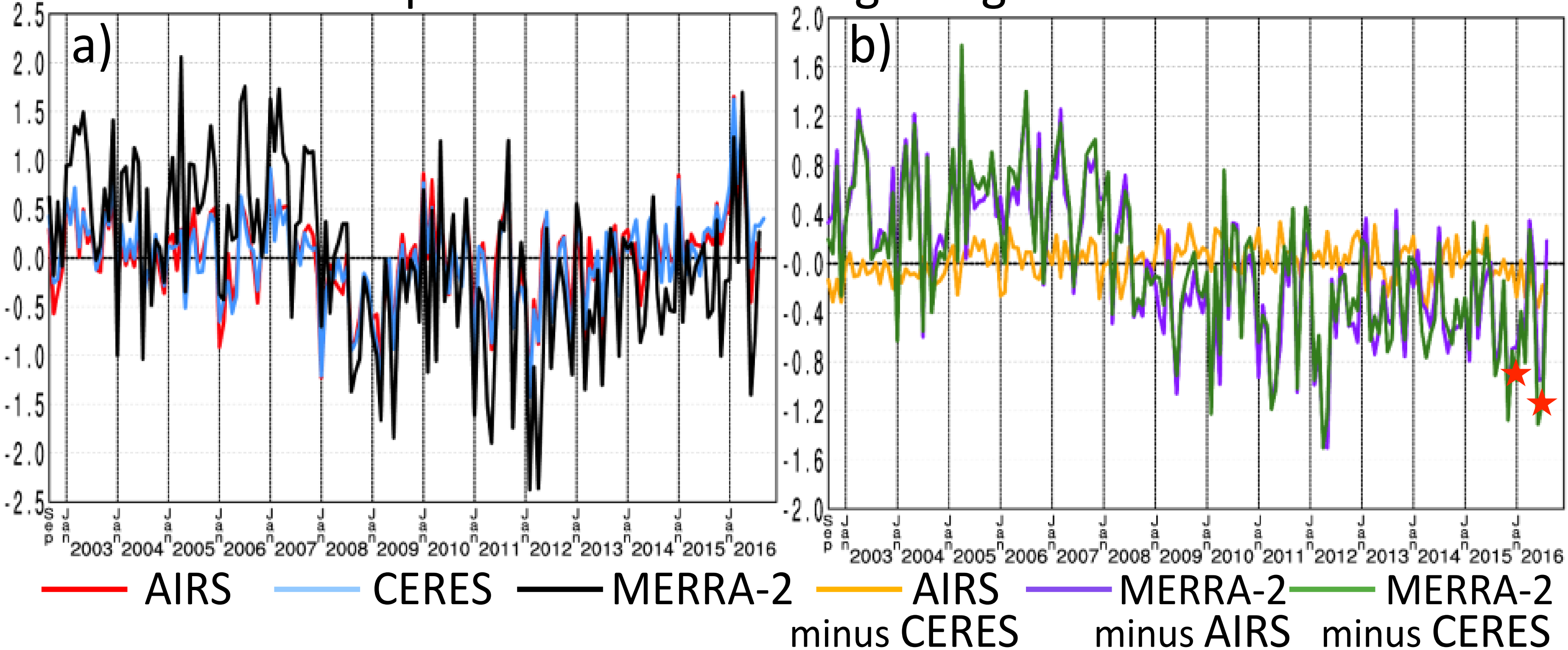


All OLR data sets show similar, but not identical seasonal cycles. AIRS is biased about 3 W/m^2 high compared to CERES, but with very small seasonal cycle differences. MERRA-2 OLR has larger seasonal cycle differences from AIRS and CERES, and appears to have a spurious negative OLR trend as well.



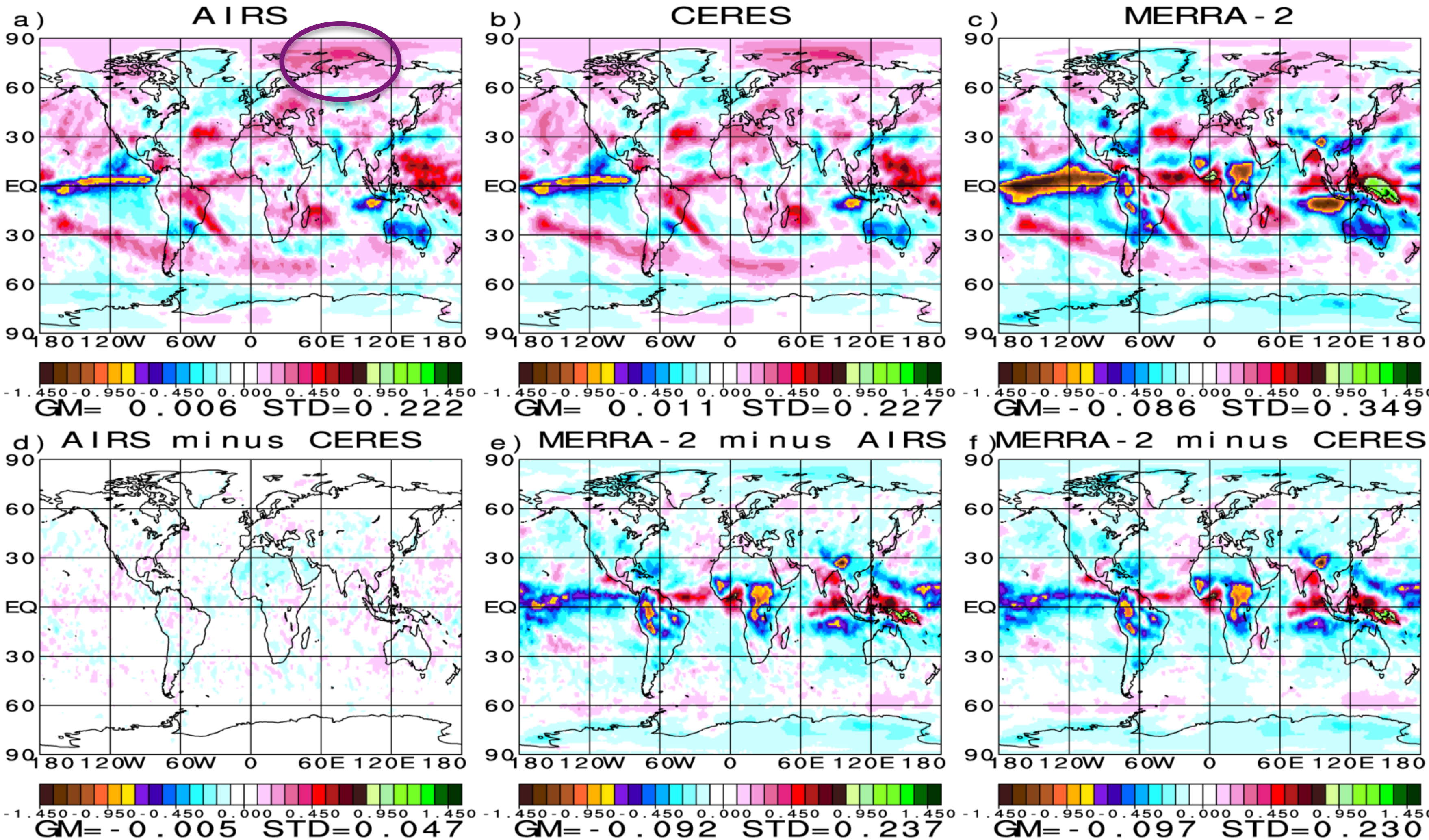
AIRS January OLR global mean climatology is 240 W/m^2 , 2.71W/m^2 higher than CERES. The Spatial Standard Deviation (STD) of their difference is 2.58 W/m^2. The spatial differences are relatively flat. In the global mean sense, MERRA-2 is closer to CERES, but the STD of their differences is very large, with cancelling differences in the tropics.

Global Outgoing Longwave Radiation Anomaly (Watts/m^2) September 2002 through August 2016



AIRS and CERES Global Mean OLR anomalies typically match to within 0.2 W/m^2 throughout the time period under study. MERRA-2 OLR anomalies are significantly more positive than those of CERES and AIRS before January 2009, and significantly more negative after that date. Something changed in MERRA-2, perhaps resulting from a new data source used in the analysis.

OLR ARCs ($W/m^2/yr$) September 2002 through August 2016



Correlation = 0.978 Correlation = 0.744 Correlation = 0.761

AIRS and CERES show a very slight global mean increase in OLR. Both agree very well in all details. MERRA-2 show a large spurious decrease in OLR, which occurs almost everywhere, especially in the tropics. El Niño induced OLR ARCs are greatly exaggerated and contains spurious negative features over Africa and South America.

Summary: *Part I*

1. AIRS and CERES OLR time series agree extremely well in all aspects.

    - This agreement validates the results of both data sets.
    - Agreement of AIRS OLR with CERES also validates to some degree the AIRS retrieved geophysical parameters.

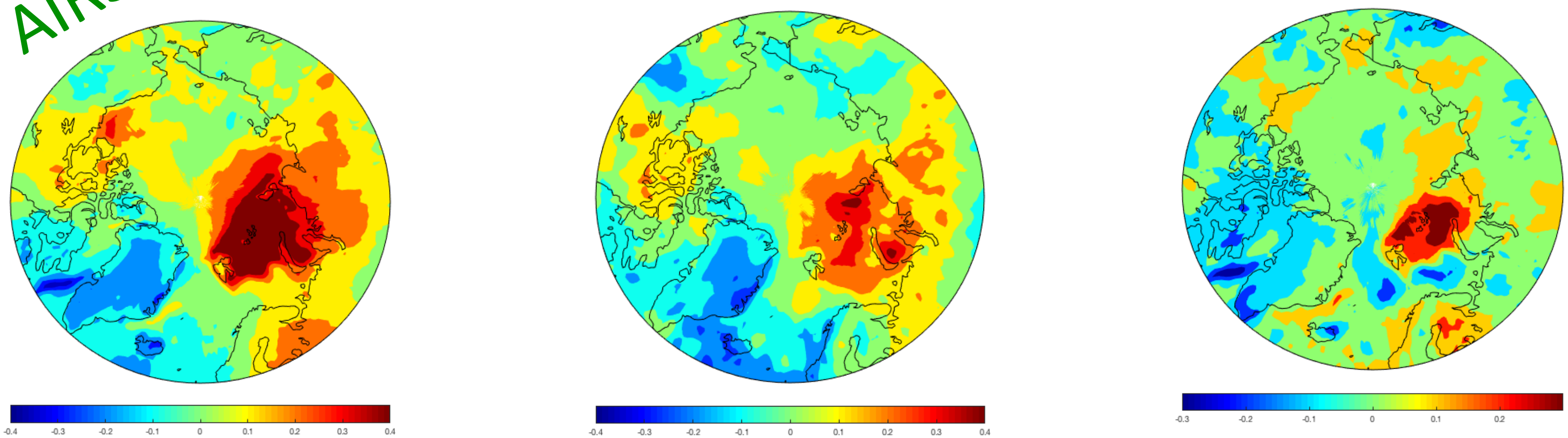
2. Some aspects of the MERRA-2 OLR data set perform reasonably well.

    - The MERRA-2 OLR data set has a discontinuity which results in a large spurious global mean OLR trend.
    - MERRA-2 OLR has large errors in the tropics related to convective cloud cover.

Part II. OLR changes in Arctic

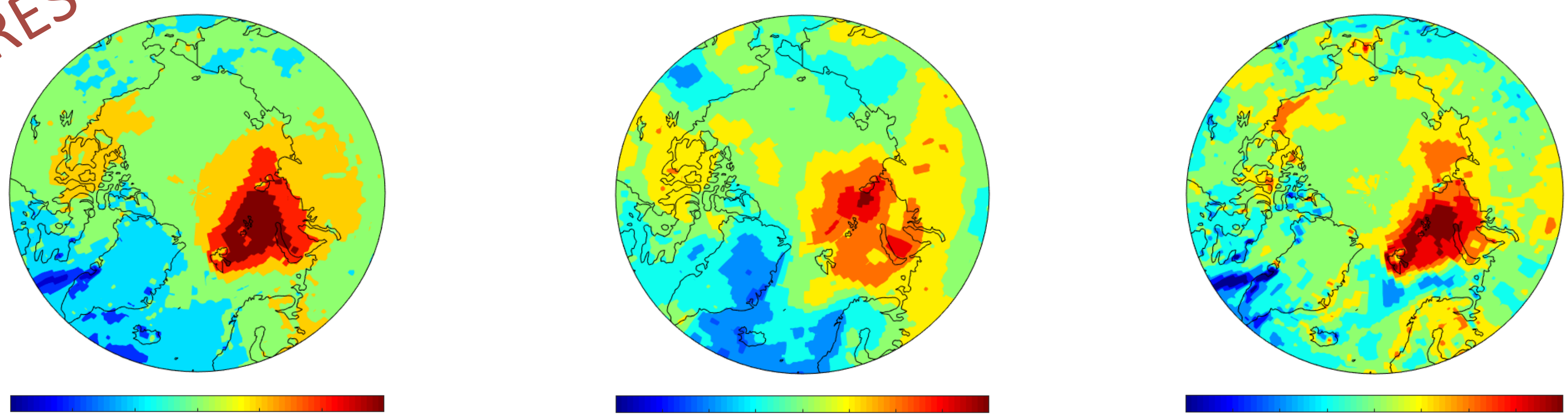
ARCs of OLRclr, OLR, and LWCRF (OLRclr – OLR): 2002-2016

AIRS

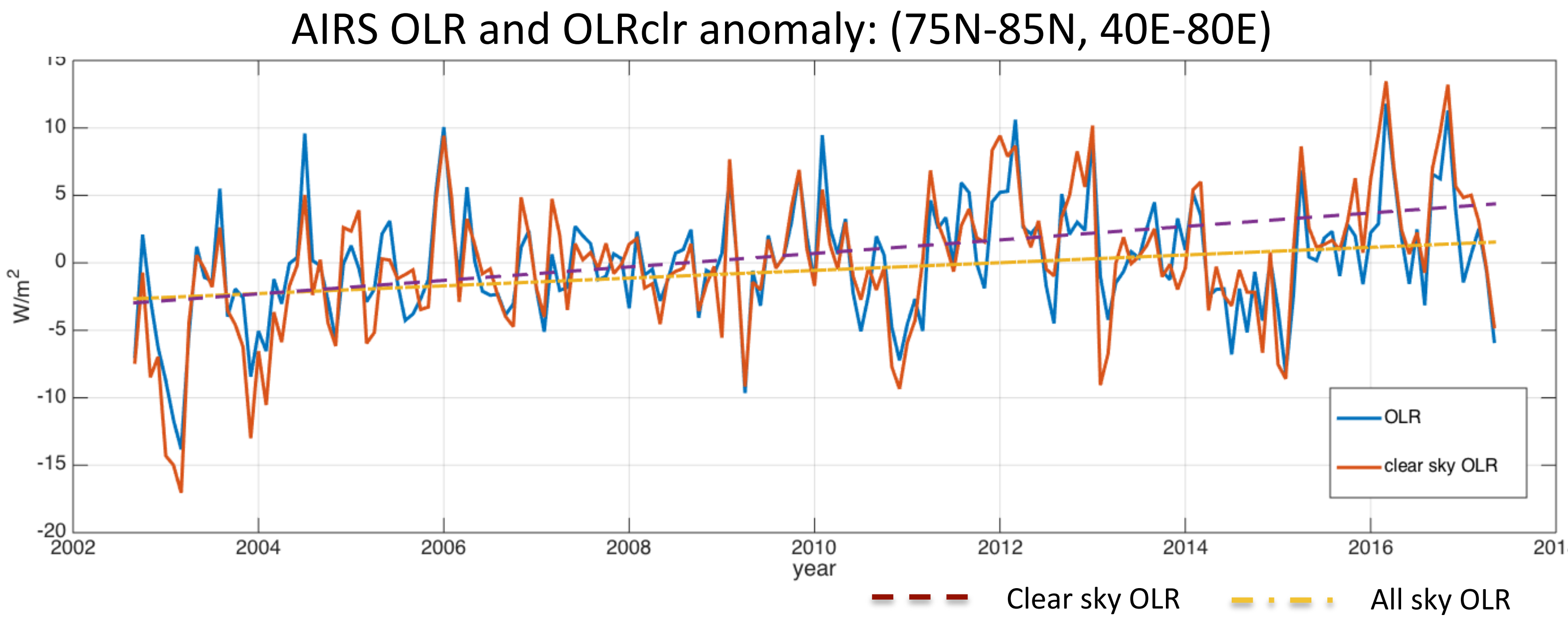


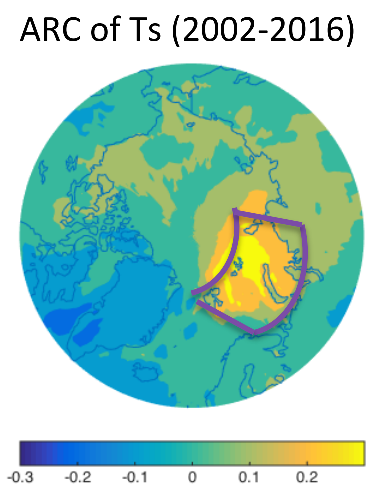
OLRclr ARCs (W/m²/yr) OLR ARCs (W/m²/yr) LWCRF ARCs (W/m²/yr)

CERES



Clear sky OLR increased more than 5W/m² during last 14 years of AIRS period,
over Arctic Barants and Kara seas, suggesting increase of clouds and surface temperature over these regions.

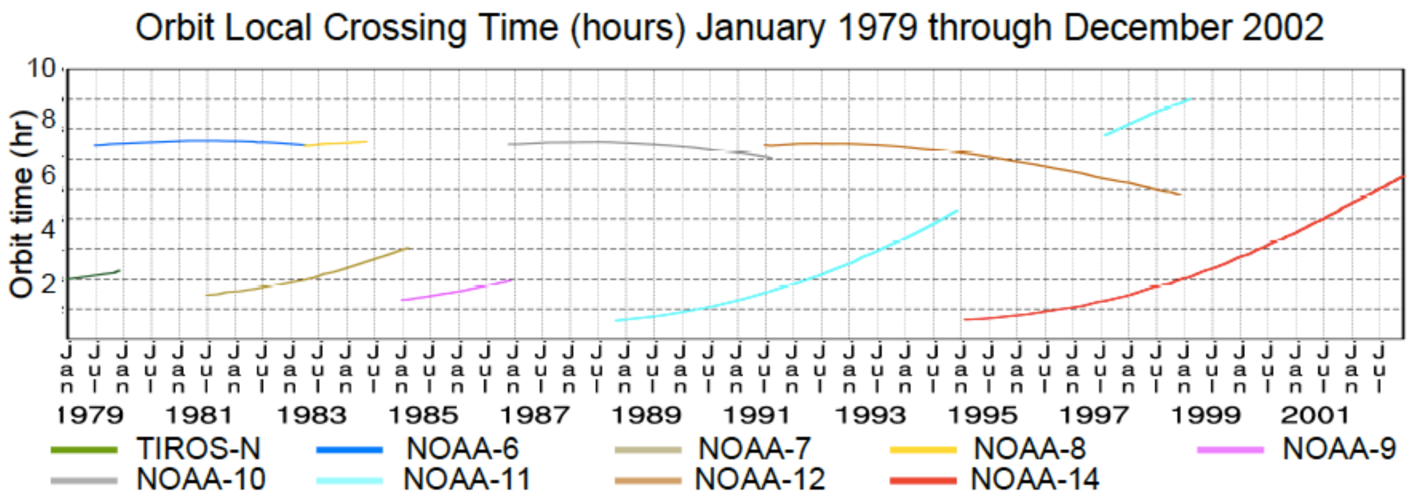




- Clear sky OLR increased more rapidly than OLR
- The OLR changes can be resulted from the recent surface warming
- LWCRF also increased, since clear sky OLR is more sensitive to surface temperature

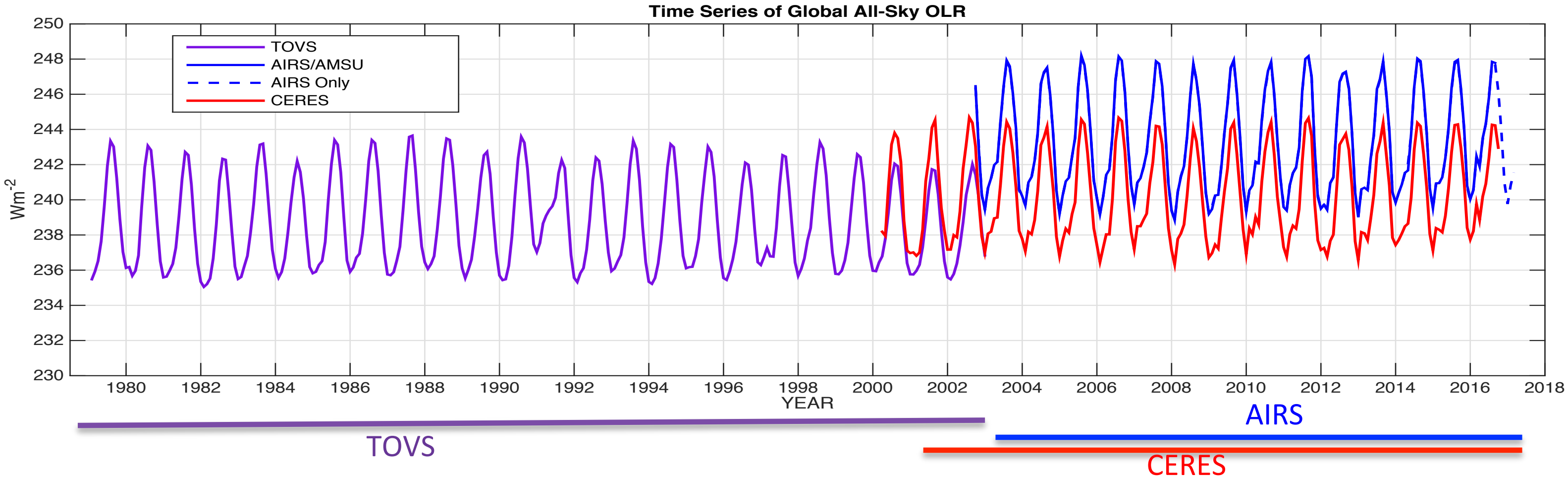
Why TOVS?

- 24 years from Pathfinder Path-A



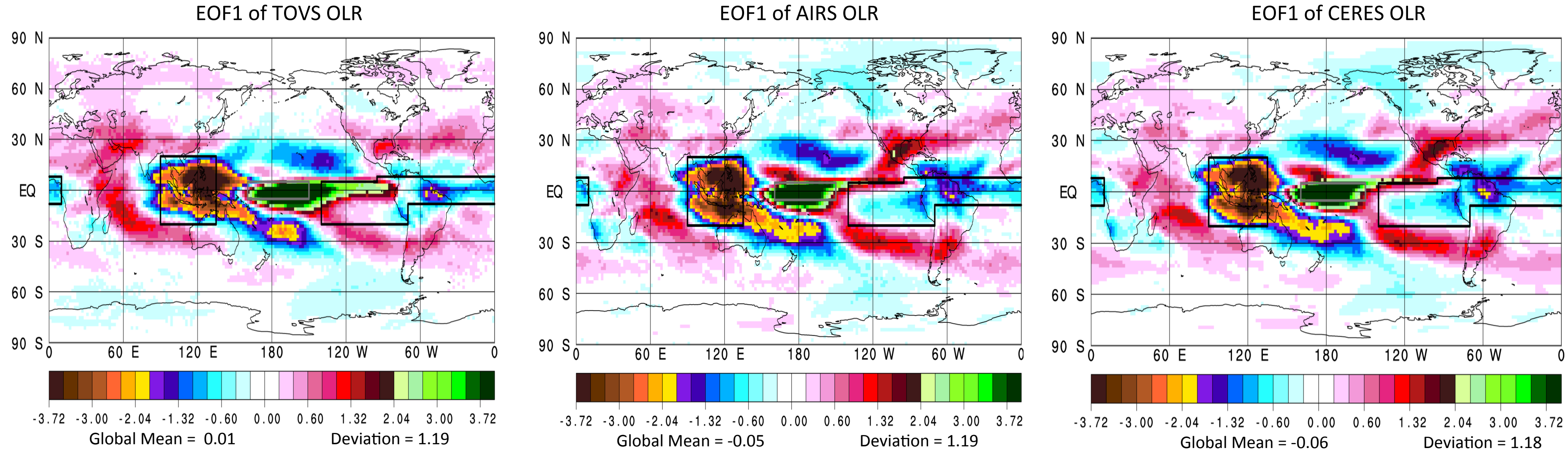
- OLR is calculated with analogous retrieval method with AIRS, adjusted to AIRS time, even with limitations on RTA and orbit drifts
- Still capable to improve the data set

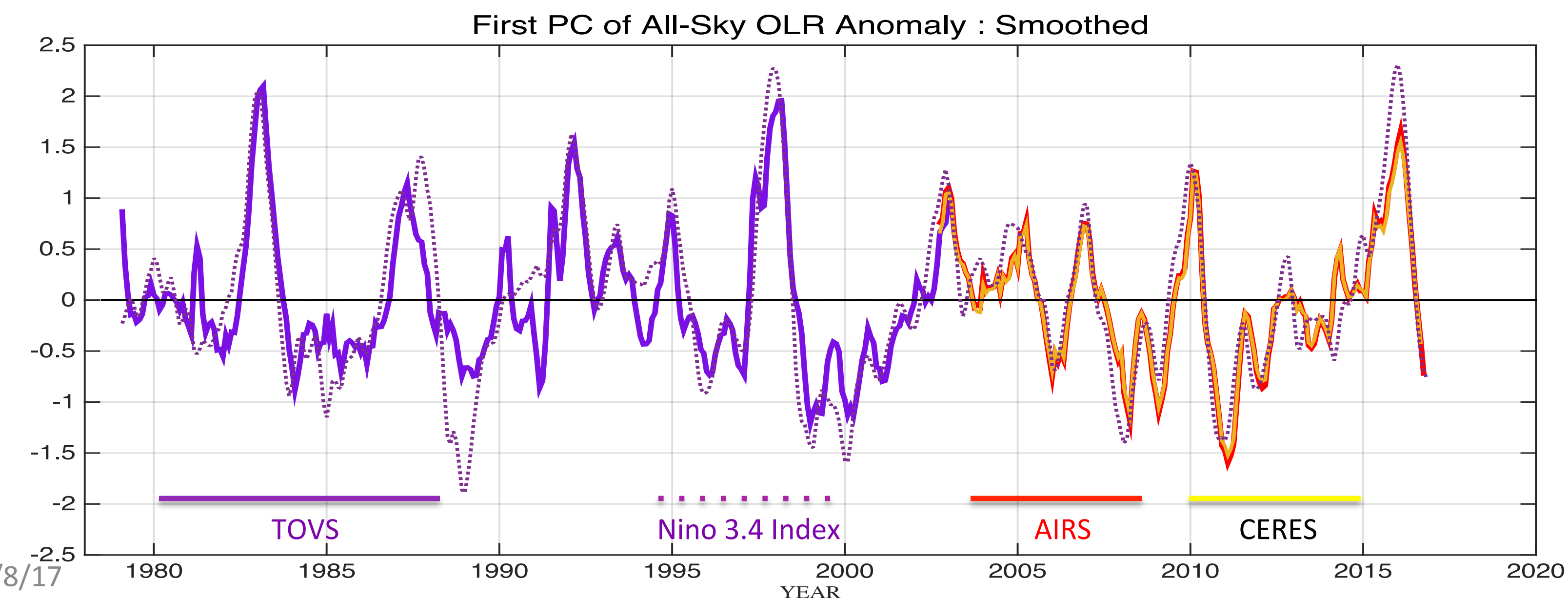
Offsets in OLR datasets



Data Set (start date – end date)	Global: 90S-90N (W/m²)	Tropical: 30S-30N (W/m²)	Analysis Period
TOVS V-1 (01/1979 – 12/2002)	238.78 ± 2.99	259.1410 ± 1.73	09/1979-08/2002
AIRS/AMSU V-6 (09/2002 – 09/2016)	243.34 ± 2.91	264.03 ± 1.65	09/2002-08/2016
AIRS Only V-6 (09/2002 – present)	243.31 ± 2.87	264.04 ± 1.63	09/2002-08/2016
CERES Edition 2.8 (03/2000 – 11/2016)	239.75 ± 2.69	259.68 ± 1.42	09/2002-08/2016
CERES Edition 4.0 (03/2000 – present)	240.32 ± 2.68	260.33 ± 1.41	09/2002-08/2016
Suomi-NPP CrIS (01/2012 – present)	Will be available In 2018	Will be available In 2018	N/A

Comparison of EOFs and PCs from TOVS, AIRS, and CERES OLR Anomaly

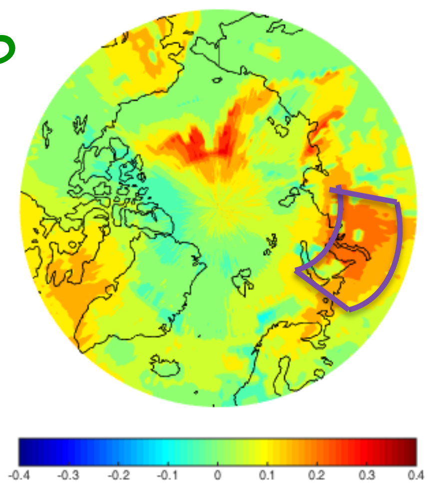




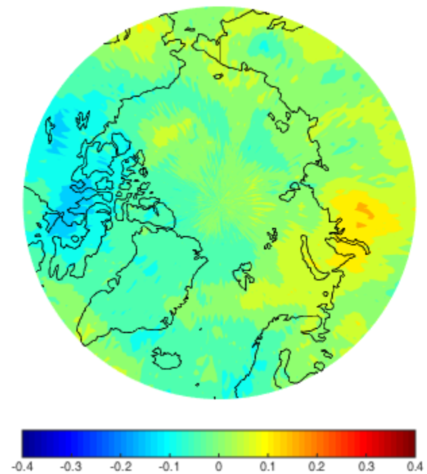
1979 - 2002 vs 2002 - 2016

TOVS

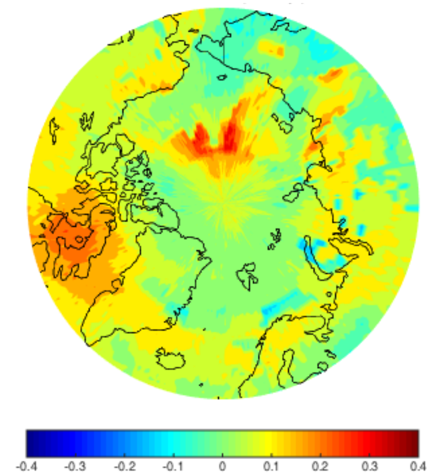
OLRclr ARCs (W/m²/yr)



OLR ARCs (W/m²/yr)

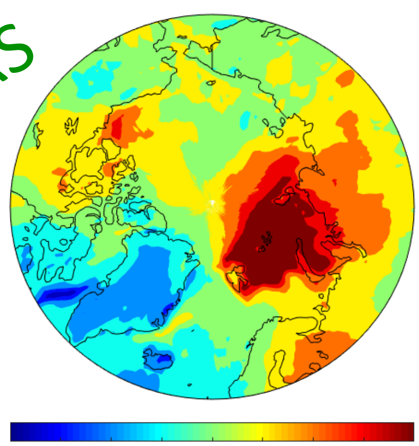


LWCRF ARCs (W/m²/yr)

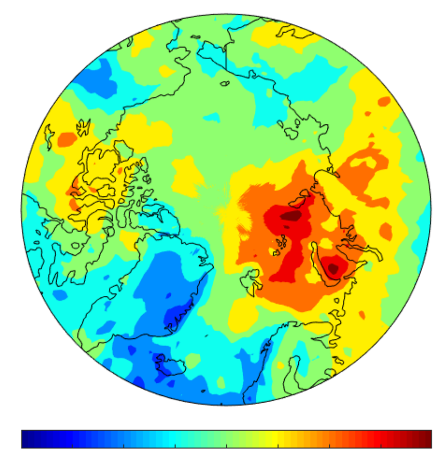


AIRS

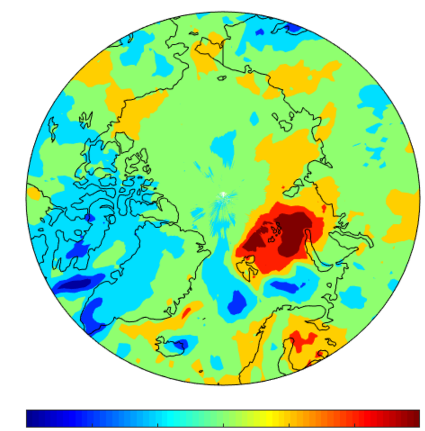
OLRclr ARCs (W/m²/yr)



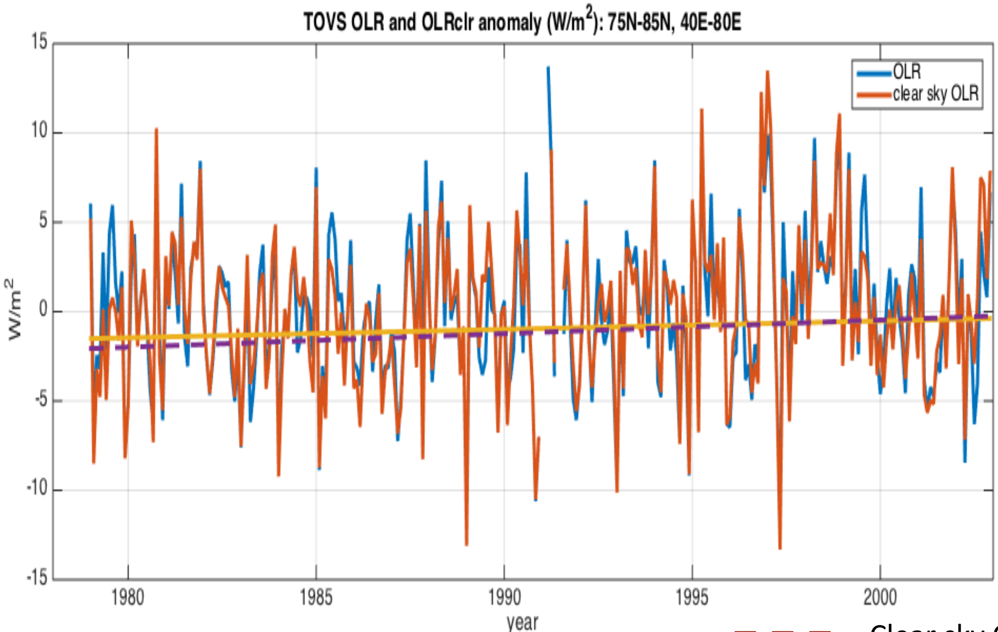
OLR ARCs (W/m²/yr)

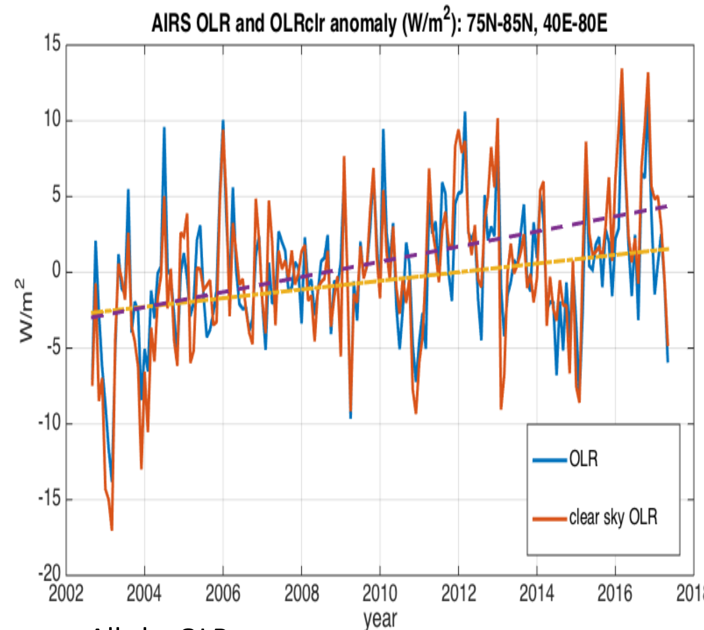


LWCRF ARCs (W/m²/yr)



AIRS OLR and OLRclr anomaly: (75N-85N, 40E-80E)



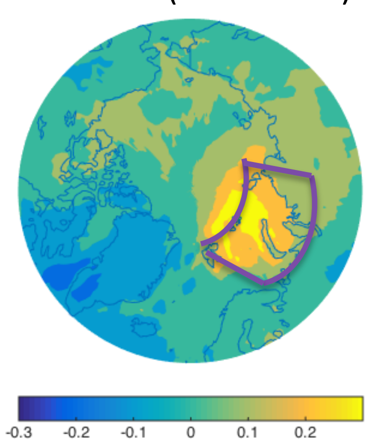


Clear sky OLR   All sky OLR

24 yrs TOVS: 1978: 2002

14 yrs AIRS: 2002: 2016

ARC of Ts (2002-2016)



Summary: *Part II*

- AIRS surface temperature shows arctic warming focused in Barents and Kara Seas.
- AIRS and CERES OLR data shows that OLR and LWCRF show significant increase over Barents and Kara Seas.
- TOVS OLR data show moderate change over those regions with slow increase.